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INTERPRETATION OF RADIOCARBON DATA AND ISOTOPIC COPMOSITION OF CARBONATE DEPOSITS FROM VILNIUS ENVIRONS, LITHUANIA

Summary. Geological interpretation of analythical data, studies of radiocarbon ages and stable isotopiccompositions of carbon and oxygen in the carbonate deposits from Vilnius environs helps to solve problems of chronology, climatic conditions of sedimentation and genesis of the Late Glacial and Holocene carbonate sediments and so on.

INTERPRETACJA DANYCH RADIOWĘGLOWYCH I SKŁADU IZOTOPOWEGO OSADÓW WĘGLANOWYCH Z REJONU WILNA NA LITWIE

Streszczenie. W rejonie Wilna spotkać można zróżnicowane genetycznie, rozproszone osady węglanowe. Pomiarom składu izotopowego węgla i tlenu oraz datowaniom radiowęglowym poddano dwa typy osadów: martwice wapienne i węglany cementujące zlepieńce.

The Late Quaternary chemogenic carbonates of different genesis are widespread in Vilnius environs. The radiocarbon age and isotopic composition has been studied by us of two following varieties of these carbonaceous deposits:

1. lacustrine carbonaceous tuffs, occuring on terraces of Green Lakes (Žalieji ežerai): Kryžiuočiai lake and
2. carbonate, cement of conglomerates in deposits of the 3-rd terrace above the flood plane of river Neris in Lazdynai meander.

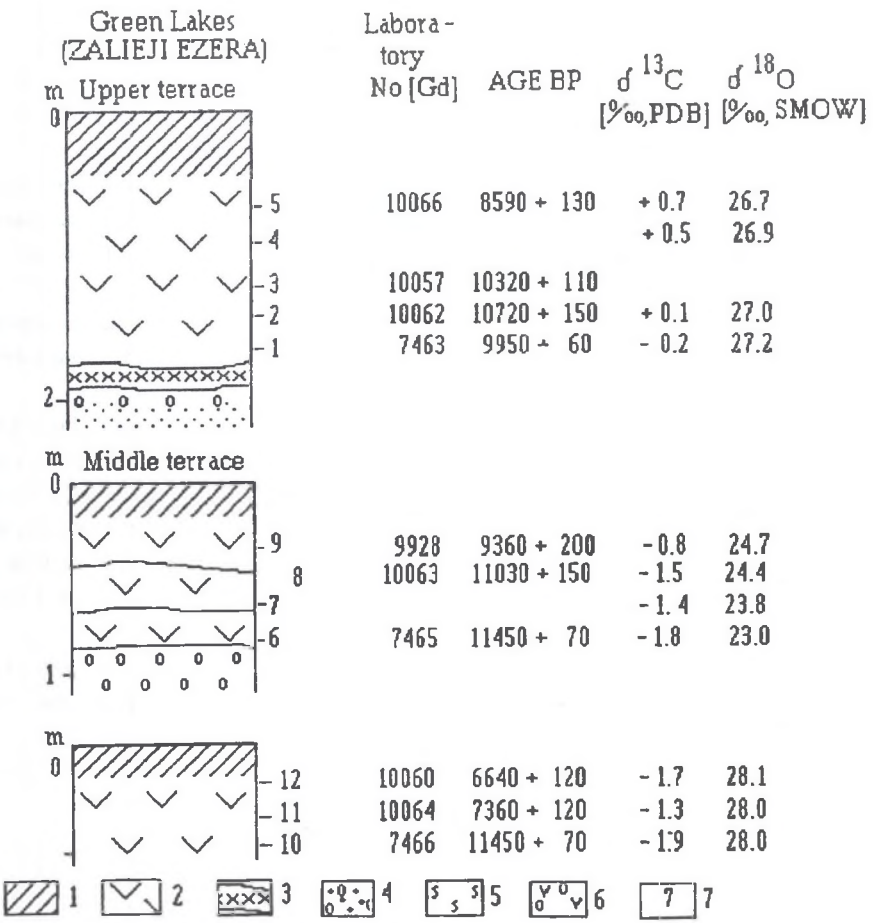
Geological and radiocarbon age of this terrace - Bolling-Middle Dryas. The obtained results are given in the table 1.

Table 1

Radiocarbon age and content of isotopes ^{13}C and ^{18}O of carbonates from Vilnius environs

No.	Sample, No	Depth of occurrence, m	Laboratory No	Age, years ago	^{13}C(‰) (PDB)	^{18}O(‰) (SMOW)
	Conglomerates Gudeliai					
1.	Gu 5/93	1.76-1.80	Gd-7468	13480 ± 70	-5.7	21.7
2.	Gu 4/93	3.31-3.36	Gd-7469	9380 ± 70	- 7.0	21.7
	Lazdynai					
3.	La 3/93	0.70-0.75	Gd-7472	10230 ± 60	- 7.0	22.0
4.	La 2/93	1.10-1.15	Gd-7470	9400 ± 60	- 8.4	22.5
5.	La 1/93	1.84-1.86	Gd-7467	7840 ± 40	- 7.8	22.4
	Lacustrine Tufa Green Lakes (Žalieji Ežerai) Upper terrace					
6.	Žal.ež.5/93	0.75-0.80	Gd-10060	8590 ±130	+ 0.7	26.7
7.	Žal.ež.4/93	0.95-1.00			+ 0.5	26.9
8.	Žal.ež.3/93	1.20-1.25	Gd-10057	10320±110		
9.	Žal.ež.2/93	1.40-1.45	Gd-10062	10720±150	+ 0.1	27.0
10.	Žal.ež.1/93	1.65-1.70	Gd- 7463	9950± 60	- 0.2	27.2
	Middle terrace					
11.	Žal.ež.9/93	0.45-0.50	Gd-9228	9360±200	- 0.8	24.7
12.	Žal.ež.8/93	0.60-0.64	Gd-10063	11030±150	- 1.5	24.4
13.	Žal.ež.7/93	0.69-0.72			- 1.4	23.8
14.	Žal.ež.6/93	0.75-0.78	Gd-7465	11450± 70	- 1.8	23.0
	Lower terrace					
15.	Žal.ež.12/93	0.45-0.50	Gd-10066	6640±120	+ 1.7	28.1
16.	Žal.ež.11/93	0.67-0.70	Gd-10064	7360±120	+1.3	27.6
17.	Žal.ež.10/93	0.75-0.80	Gd- 7466	7650± 70	+1.9	28.0

The Green Lakes (Žalieji ežerai) are located in the basin of river Riešė, which falls into river Neris some kilometers above the Vilnius city. This group of lakes includes Kryžiuočiai, Gulbinai, Mažieji Gulbinai, Raistelis, Baraukos Akis and Akis lakes. We have studied the fresh water carbonate tufa from the Kryžuočiai lake. The tufa are spread at thermokarst subsidence levels of peninsula in the south–eastern part of lake (fig.1).



Laboratory No [Gd]	AGE BP	$\delta^{13}C$ [‰, PDB]	$\delta^{18}O$ [‰, SMOW]
10066	8590 + 130	+ 0.7	26.7
		+ 0.5	26.9
10057	10320 + 110		
10062	10720 + 150	+ 0.1	27.0
7463	9950 + 60	- 0.2	27.2
9928	9360 + 200	- 0.8	24.7
10063	11030 + 150	- 1.5	24.4
		- 1.4	23.8
7465	11450 + 70	- 1.8	23.0
10060	6640 + 120	- 1.7	28.1
10064	7360 + 120	- 1.3	28.0
7466	11450 + 70	- 1.9	28.0

Fig. 1. Sections of carbonate tuffs on terraces of Kryžiuočiai Lake with result of investigations: 1–soil, 2–chemogenic carbonates, 3–peat, 4–sand and gravel, 5–illuvial horizon, 6–diagonal stratification, 7–pebble coble conglomerate with carbonate cementation, 8–number of sample

Rys. 1. Przekrój terrasy jeziora Kryžiuočiai zawierającej osady węglanowe (wraz z wynikami badań); 1 – gleba, 2 – węglany chomogeniczne, 3 – torf, 4 – piaski i żwiry, 5 – poziom iluwium, 6 – zlepieńce złożone z otoczaków z cementem węglanowym

Forming of lacustrine calcareous deposits has depended on relief, i.e. on morphology of lake basin (Bartosh, 1976). The groove of the Žalieji lake occur in the marginal zone of the last glaciation. The monticulate–morainic belt of lakes is distinguished by extremely intricate glacial relief and variability of forming material. Coarse–grained material of frontal–morainic deposits and sandy–gravel fluvioglacial deposits are permeable horizons, which favour underground water flow and washing out of carbonates.

Accumulation of the loose pelitomorphic mass of calcium carbonate has occurred owing to brought carbonates by springs waters and precipitated in the lacustrine basin. Deposition of calcareous sediment has occurred, mainly, in foreshore part of the lake, in marginal parts of bottom slopes and in its deep part too.

The investigated lake Kryžiuočiai is in the mature phase. Žalieji lakes are located in two fluvioglacial rills, elongated in NW - SE direction. The basin of Kryžiuočiai lake is located in the glacial groove.

Terraces of the Žalieji lakes have been studied by A. Stanaitis (1963) and bound up with terraces of the rivers Neris and Ričšė. He has attributed the terrace, studied by us, to the lower terrace of thermokarst subsidence. It has remained in the south-eastern part of the Kryžiuočiai lake, where we have studied the carbonaceous tuffs. In this way, the studied terraces levels are attributed to the areas of thermokarst subsidence, which at present are found from 3 to 10 m above the water–level of the lake. The terrace areas are rough, narrow and indistinct. The thickness of carbonate deposits reaches up to 4 m.

The deposits are characterized by relative purity and homogeneous composition. The fresh water calcareous earth (alm) is represented by fine–grained pelitomorphic, flour–like, cryptocrystalline mass of calcite aggregates of 0.5–0.05 mm in size. Rare small shells of molluscs are found too. The texture – fine–horizontally layered. The content of $CaCO_3$ exceeds 90%, reaching up to 95–97%. Sometimes deposits are polluted by mineral and organogenous admixtures. The content of $CaCO_3$ in the vertical section of carbonate deposits of the Kryžiuočiai lake varies from 54.05 to 96.25%.

The most ancient (Alleroed-Late Dryas) age of lacustrine carbonates is established on the middle terrace, slightly younger (Late Dryas–pre–Boreal) – on the upper and most young (Boreal–Atlantic) – to the lower terrace (fig.1).

Age limits of radiocarbon dating of the lacustrine carbonates–upper 10720±150 and lower 6640±120 years. Thus, the age interval includes about 4000 years. Radiocarbon datings of carbonate tufas layers well correspond with variations of climate (Subarctic–Atlantic), fixed by content of oxygen isotope (^{18}O) in carbonates. Thus the isotopic composition confirms correctness of radiocarbon datings. Combined use of age and isotopic composition determinations allows not only to solve problems of chronology and palaeogeography but also gives the objective data for elucidation of lacustrine carbonates formation.

Rate of carbonate sedimentation in Green Lakes (Žalieji ežerai), calculated on basis of determination of radiocarbon age data, has been almost the same during the whole

studied time interval, i.e., about 0.03-0.04 mm per year. Content of stabile carbon isotope ^{13}C distinctly shows formation and sources of carbonate sediment. During the Late Glacial the inwashed allogenic carbonate has played a considerable part, and during Holocene – the newly formed, chemogenic.

The spore–pollen and diatoms analyses of the Kryžiuočiai lake has been carried out by M.Kabailienė (1963). She has determined by spore–pollen analyses data that the beginning of carbonate formation as Alleroed too. According to these data, during the first half of Alleroed time, about 11000- 12000 years ago, a considerable shallowing of the lake has occurred. By the end of Alloroed time the lake has become deeper. Since this time in the Kryžiuočiai lake the sedimentation of fresh water carbonate tufa has begun (the middle terrace - radiocarbon dates 11450±70 – 11030±150 years) (fig.1). At the end of Late Dryas – beginning of pre-Boreal the carbonates, studied by us, have deposited on the upper terrace (radiocarbon dates 10320±110 – 8590±130 years). According to sedimentation data and results of spore-pollen spectres and diatoms studies, during the pre-Boreal the lake has become shallow once more. To the end of the Boreal the water level has risen again, and the accumulation of fresh water carbonacte tufa has begun again. Since that time its accumulation in the basin of Kryžiuočiai lake lasts with breaks of short duration up to now.

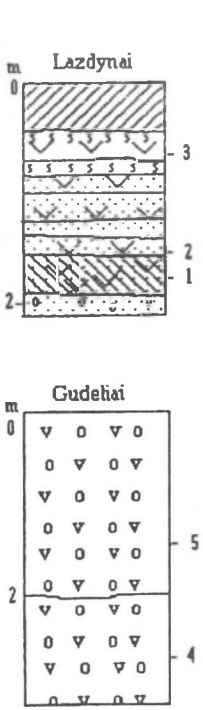
On the lower terrace the dated by us carbonates have accumulated during the Atlantic period . The rise in temperature during the Alleroed time (26.7-27.2‰, $\delta^{18}O$) and warm climate during the Atlantic time (27.6-28.1‰, $\delta^{18}O$) are well reflected by isotopic oxygene composition (Table 1.). The Upper Dryas more cool conditions are reflected by isotopic composition too (23.0-24.7‰, $\delta^{18}O$). Thus, the coincidence of conclusions, drawn on the grounds of studies of radiocarbon age and isotopic composition and the data of spores–pollen and diatoms analyses, is observed.

Earlier the pre-Boreal – Boreal radiocarbon age (9950±140 – 8620±100) of carbonaceous tuffs from the 1-st and 2-nd terraces of the groove lake Viļkokšnis (Gaigalas, 1974, Galčienė, 1976) has been determined. J.Galčienė (1976) has determined four stages of carbonates formation in lakes of Lithuania. According to her data, accumulation of carbonates in lakes has begun during the Alleroed time – about 12000 – 10800 years ago. The second stage has lasted during the Late Dryas and pre-Boreal period (10800 – 9000 years ago). The pure carbonate tufa, in her opinion, have deposited in all lakes during the third stage – during the pre-Boreal and the Boreal periods (9000 – 7900 years ago). Apparently, this stage coincides with maximum of carbonate formation in lakes of Lithuania. The 4th stage of carbonate formation is distinguished during the sub-Boreal period (4050 – 3250 years ago).

The lower lacustrine terraces, dated by radiocarbon method, have arose, as a result of climatic changes, rivers incisions and variation of water level, thus, some differences can be observed in different lakes.

Not less interesting and useful results have been obtained during studies of carbonate count in conglomeraty, which enable to explain precisely their genesis, which earlier has been considered as problematic.

Conglomerates are found under feably permeable varved clay, adhered to its floor (fig.2).



Laboratory No [Gd]	AGE BP	$\delta^{13}C$ [‰,PDB]	$\delta^{18}O$ [‰, SMOW]
7747	10230 ± 60	-7.0	22.0
7470	9400 ± 60	-8.4	22.5
7467	7840 ± 40	-7.8	22.4
7468	13480 ± 70	-5.7	21.7
7469	9380 ± 70	-7.0	21.7

Fig. 2. Sections of conglomerates with results of investigations. Legend see under fig.1

Rys. 2. Przekrój zlepieńców wraz z wynikami badań. Objaśnienia jak do rys. 1.

They have been formed in gravel layer. The carbonacte material becomes younger and younger in these conglomerates with depth, i.e., the appropriated age inversion is observed. It confirms, that grouth of conglomerates has occurred into depth by rate about 0.4–0.6 mm/year. Apparently, during the Late Glacial accumulation of carbonaceous material has taken place more rapidly by 1.5–1.8 times, than during the Holocene. Formation of carbonates has occurred at some depth from surface, thus the temperature conditions have been simular during the whole interval of time from 13480±70 to 7840±40 years, almost for a period of 6000 years. However, temperatures of carbonates sedimentation have been slightly higher during Holocene, than in Late Glaciation. ^{13}C content shows that the essential part of carbonates is inwashed allogenic, redposited from varves clay.

On the principle scheme (fig.3) the model of formation process of pebbly conglomerates, cemented by chemogenous sinters carbonates, is given.

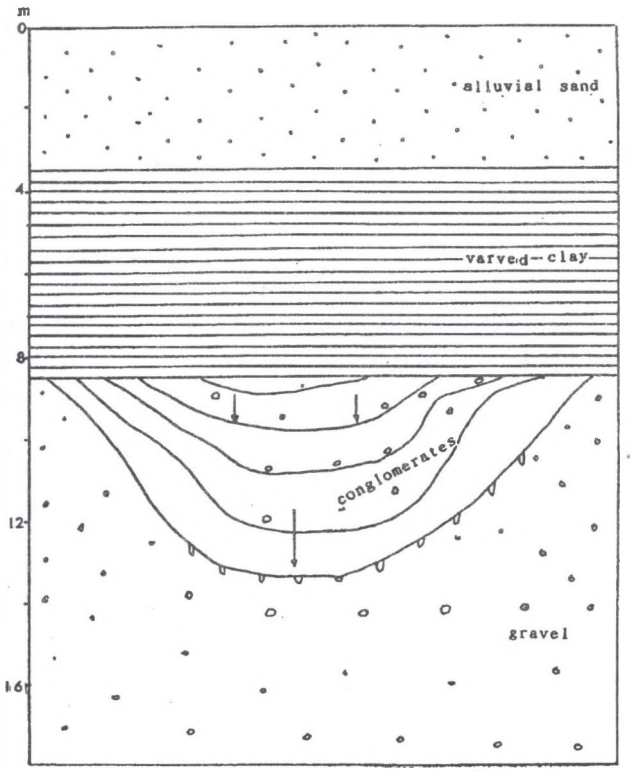


Fig. 3. Scheme of conglomerate formation. Arrows shows the growth of conglomerate carbonates

Rys. 3. Schemat formacji zlepieńców. Strzałki wskazują kierunek wzrostu formacji zlepieńców

Geological interpretation of analythical data, studies of radiocarbon age and isotopic compositions of carbonaceous deposits helps to solve successfully problems of chronology, temperature conditions of sedimentation, genesis of the Late Glacial and Holocene carbonacte sediments and so on.

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Streszczenie

W rejonie Wilan spotkać można zróżnicowane genetycznie, rozproszone osady węglanowe. Datowaniom radiowęglowym oraz pomiarom składu izotopowego węgla i tlenu poddane zostały dwa typy osadów: 1) martwice wapienne powstle w środowisku sedymentacji limnicznej, widoczne na terasach Zielonego Jeziora (Zaliei ezerai) - Kriziuociai Lake oraz 2) węglany cementujące zlepieńce w osadach trzeciej terasy, powyżej płaszczyzny powodziowej rzeki Neris (w meandrze Lazdynai). W wyniku datowań radiowęglowych najstarszy wiek osadów jeziornych został uzyskany dla osadów pochodzących z terasy środkowej, nieco młodszy (YD/PB) - z górnej i najmłodszy (BO/AT) - z terasy dolnej. Wiek radiowęglowy wspomnianych osadów zawiera się w przedziale od 10720±150 do

6640±120 BP; obejmuje zatem około 4000 lat. Wiek poziomów martwicowych dobrze koresponduje ze sprzyjającymi warunkami klimatycznymi ich sedymentacji, zapisanymi w składzie izotopowym tlenu w osadzie. Szybkość sedymentacji węglanów z Zielonego Jeziora, oszacowana na podstawie datowań radiowęglowych posiada stałą wartość w całym okresie ich sedymentacji i wynosi ok. 0.03–0.04 mm na rok. Koncentracja stabilnego izotopu węgla ^{13}C wskazuje na różne pochodzenie węgla w osadach, w różnych okresach ich formowania.

Interesujace wyniki uzyskane zostały również z badań wapiennych cementów w zlepieńcach znalezionych w terasie rzeki Neris. Zostały one uformowane w warstwie żwirów. Zaobserwowano inwersję wieków cementów – w miarę wzrostu głębokości pobranych próbek ich wiek staje się młodszy. Potwierdza to fakt iż narastanie zlepieńców postępuje w głąb osadu, zaś szybkość ich narastania wynosi około 0.4–0.6 mm na rok. Sprzyjające warunki klimatyczne formowania się osadu występowały w ciągu około 6000 lat w przedziale wieków od 13480±70 do 7840±40 lat BP.